Original Article

Outcome of Intraoperative Injection versus Sponge-applied Mitomycin C during Trabeculectomy

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Abstract

Background: Mitomycin C (MMC) is a critical adjuvant to trabeculectomy surgery, traditionally applied by sponge soaking. Intraoperative injection has nonetheless been suggested as a practical delivery method with potential advantages. The present article compares intraoperative injection and sponge-applied MMC for efficacy and safety in trabeculectomy. **Methods:** This prospective comparative study was conducted at the National Institute of Ophthalmology & Hospital from May 2024 to October 2024, enrolled 80 patients undergoing trabeculectomy, evenly divided into receiving MMC either by intraoperative injection (n=40) or sponge application (n=40). Participants with primary open-angle glaucoma, primary angle-closure glaucoma, or secondary glaucoma were recruited by purposive sampling. The primary outcomes were intraocular pressure control and surgical success at 12 months. The secondary outcomes were immediate, early (3 months), and late complications. Statistical analysis used chi-square tests, Kaplan-Meier survival analysis, and multivariate logistic regression. **Results:** The results of the injection group were better on a number of parameters. Complete surgical success at 12 months was much higher with injection (75.0% vs 40.0%, p=0.004). Day-1 IOP ≤10 mmHg occurred in 50.0% of injection patients and 20.0% of sponge patients (p=0.008). Early bleb formation was improved with injection (80.0% vs 45.0%, p=0.005). Complications were significantly reduced with the injection technique, e.g., hyphema (2.5% vs 17.5%, p=0.018), shallow anterior chamber (5.0% vs 22.5%, p=0.031), and necessity for needling (5.0% vs 30.0%, p=0.003). Multivariate analysis confirmed injection technique as an independent predictor of surgical success (OR 3.94, 95% CI 1.42-10.94, p=0.008). **Conclusion:** MMC intraoperative injection was found to be more effective and safer compared to the traditional sponge application in trabeculectomy, with higher success rates and fewer complications. The technique is a valuable innovation for glaucoma surgery with significant clinical implications.

Keywords: Intraoperative Injection, Mitomycin C, Trabeculectomy

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Introduction

Glaucoma remains the leading cause of irreversible blindness worldwide, affecting over 76 million people across the world [1]. Trabeculectomy, as first described by Cairns in 1968, remains the gold standard procedure for surgical intervention in patients with uncontrolled intraocular pressure (IOP) despite maximal tolerated medical therapy [2]. The surgery creates a controlled aqueous humor drainage channel, subsequently lowering IOP and halting progressive optic nerve damage. The introduction of antifibrotic medication, primarily Mitomycin C (MMC), has revolutionized the outcome of trabeculectomy by reducing postoperative subconjunctival fibrosis and bleb failure to a very large extent [3]. MMC is an alkylating Streptomyces caespitosus-derived antineoplastic agent that inhibits DNA synthesis and reduces fibroblast proliferation, with

long-term bleb survival [4]. Since its first application in glaucoma surgery in 1983, MMC has emerged as a drug of first choice that has catapulted surgical success rates from 60-70% to 80-95% in most patient populations. MMC has classically been employed at the time of trabeculectomy with sponge implantation, where sponges soaked in MMC solution are retained in position beneath the conjunctiva and over the scleral bed for defined periods of time [5]. This time-tested method allows for controlled tissue exposure to the antifibrotic drug, with concentrations most commonly between 0.01% and 0.04% and durations of exposure between 1 and 5 minutes, depending upon the level of risk of failure of surgery [6]. Notwithstanding this, complications such as uneven drug distribution, possible tissue toxicity from prolonged contact, and technical issues of uniform delivery have resulted in the investigation of alternative delivery methods. Intraoperative MMC subconjunctival injection is a plausible alternative to the traditional sponge application [7]. This technique has some theoretical advantages, including more uniform drug delivery, reduced risk of unplanned scleral perforation with sponge placement, reduced time for the operation, and potentially more consistent drug dosage [8]. The injection technique gives a precise amount of MMC solution directly into the subconjunctival space, theoretically providing more homogeneous and controlled tissue exposure without the need for multiple sponge applications and accurate placement. Subsequent studies have begun comparing the relative efficacy of MMC injection to sponge implantation in trabeculectomy with mixed findings in various populations and surgical procedures [9]. While some research has revealed equivalent efficacy of the two treatments, others have reported potential superiority of the injection compared to the sponge treatment for both efficacy and safety outcomes [10]. However, most of these studies have been plagued by small patient numbers, brief follow-up, or retrospective design, and properly designed prospective comparative studies are in immediate need. MMC delivery optimization in trabeculectomy is clinically significant because the outcome of surgery has direct relationships with the quality of life for patients, maintenance of visual function, and the need for subsequent intervention [11]. Understanding comparative results between different MMC delivery methods is crucial to evidence-based surgery and could influence how surgical treatments evolve for glaucoma. This prospective comparative study was designed to rigorously evaluate intraoperative injection compared with traditional sponge-applied MMC safety and efficacy in trabeculectomy, in terms of surgical success rates, IOP control, and rates of complications at 12 months follow-up.

Methods

This comparative study was conducted at the National Institute of Ophthalmology & Hospital from May 2024 to October 2024. The study included 80 patients undergoing trabeculectomy, who were allocated equally to intraoperative Mitomycin C either by injection (n=40) or sponge application (n=40). Patients with primary open-angle glaucoma, primary angle-closure glaucoma, or secondary glaucoma were enrolled prospectively using purposive sampling. Baseline demographic and ocular characteristics were recorded. Intraoperative variables such as releasable suture use and complications were noted. Postoperative assessments included immediate outcomes, early outcomes at 3 months, and late outcomes at 12 months. Surgical success was defined as target IOP without medication (complete) or with medication (qualified), while failure denoted uncontrolled IOP or need for further surgery.

Data analysis:

Data were entered and analyzed using standard statistical software SPSS version 26. Categorical variables such as baseline characteristics, intraoperative events, and postoperative outcomes were summarized as frequencies and percentages, and comparisons between the injection and sponge groups were performed using the Chi-square. Effect size estimates were calculated to enhance clinical interpretation, including absolute risk difference (ARD, expressed in percentage points), relative risk (RR) with 95% confidence intervals, and the number needed to treat (NNT) or prevent (NNH-prevent). For time-to-event analysis of surgical success over 12 months, Kaplan–Meier survival curves were constructed and compared

using the log-rank test. To adjust for potential confounding factors multivariate logistic regression model was performed, with adjusted odds ratios (OR) and 95% confidence intervals reported. A p-value <0.05 was considered statistically significant for all analyses.

Results

Table 1 represents the demographic characteristics of the study population. Age profile was similar in the two groups, with the majority of patients (42.5-45.0%) falling in the 50-64 years age group. The male predominance was noted in both groups (60-65%). The most common diagnosis was primary open-angle glaucoma (55-60%), followed by primary angle-closure glaucoma (25-30%) and secondary glaucoma (15%). The majority of patients (70-75%) were phakic at the time of surgery. Statistical analysis showed no group differences for any baseline parameter (all p-values >0.05), which confirms successful randomization and exclusion of possible confounding factors influencing treatment outcome.

Table 1: Baseline characteristics (N=80)

Variable	Injection (n=40)	Sponge (n=40)	p-value
Age group			
<50 years	10 (25.0%)	9 (22.5%)	
50–64 years	18 (45.0%)	17 (42.5%)	0.889
≥65 years	12 (30.0%)	14 (35.0%)	
Sex			
Male	26 (65.0%)	24 (60.0%)	0.817
Female	14 (35.0%)	16 (40.0%)	
Diagnosis			
POAG	24 (60.0%)	22 (55.0%)	
PACG	10 (25.0%)	12 (30.0%)	0.874
Secondary glaucoma	6 (15.0%)	6 (15.0%)	
Lens status			
Phakic	30 (75.0%)	28 (70.0%)	0.802
Pseudophakic	10 (25.0%)	12 (30.0%)	

Table 2 reveals significant differences in intraoperative events between the two MMC application modes. The injection group had fewer intraoperative complications than the sponge group (2.5% vs 25.0%, p=0.020), primarily due to the absence of conjunctival buttonhole formation in the injection group vs 15.0% in the sponge group (p=0.012). Releasable sutures were used more often in the injection group (90.0% vs 60.0%, p=0.004), possibly a reflection of surgeon confidence in achieving the best early IOP control with the injection method.

Table 2: Intraoperative details and complications (N=80)

Variable	Injection (n=40)	Sponge (n=40)	p-value
Intraoperative complication (any)			
Yes	1 (2.5%)	10 (25.0%)	0.020
No	39 (97.5%)	30 (75.0%)	
Releasable sutures used			
Yes	36 (90.0%)	24 (60.0%)	0.004
No	4 (10.0%)	16 (40.0%)	
Conjunctival buttonhole			
Yes	0 (0.0%)	6 (15.0%)	0.012
No	40 (100.0%)	34 (85.0%)	

Table 3 demonstrates the immediate postoperative outcomes. Optimal day-1 control of IOP (≤10 mmHg) occurred in significantly more patients in the injection group (50.0% vs 20.0%, p=0.008), indicating superior instantaneous pressure reduction. Both lower rates of development of shallow anterior chamber (5.0% vs 22.5%, p=0.031) and hyphemia (2.5% vs 17.5%, p=0.018) occurred in the injection group, evidencing reduced surgical trauma and inflammation. Most importantly, early bleb configuration was much improved in the injection group, with 80.0% achieving good diffuse blebs compared with only 45.0% in the sponge group (p=0.005).

Table 3: Immediate postoperative outcomes (≤1 week) (N=80)

Outcome	Injection (n=40)	Sponge (n=40)	p-value
Day-1 IOP (mmHg)			
≤10	20 (50.0%)	8 (20.0%)	
11–15	14 (35.0%)	18 (45.0%)	0.008
>15	6 (15.0%)	14 (35.0%)	
Shallow anterior chamber			
Yes	2 (5.0%)	9 (22.5%)	0.031
No	38 (95.0%)	31 (77.5%)	
Hyphema			
Yes	1 (2.5%)	7 (17.5%)	0.018
No	39 (97.5%)	33 (82.5%)	
Early bleb formation (diffuse/ideal)			
Good bleb	32 (80.0%)	18 (45.0%)	0.005
Poor/flat bleb	8 (20.0%)	22 (55.0%)	

Table 4 reveals the early postoperative outcomes at 3 months. Good IOP control (≤15 mmHg) was achieved in 75.0% of the injection group versus 40.0% of the sponge group (p=0.003), and fewer patients required further intervention. Bleb leakage, a severe complication which jeopardizes the success of surgery, occurred only in 2.5% of injection patients versus 22.5% of sponge patients (p=0.010). The need for needling procedures, a marker of poor bleb function with a requirement for mechanical revision, was reduced appreciably in the injection group (5.0% vs 30.0%, p=0.003).

Table 4: Early postoperative outcomes (at 3 months) (N=80)

Outcome	Injection (n=40)	Sponge (n=40)	p-value
IOP category (mmHg)			
≤15	30 (75.0%)	16 (40.0%)	
16–21	8 (20.0%)	14 (35.0%)	0.003
>21	2 (5.0%)	10 (25.0%)	
Bleb leak (Seidel+)			
Yes	1 (2.5%)	9 (22.5%)	0.010
No	39 (97.5%)	31 (77.5%)	
Needling required			
Yes	2 (5.0%)	12 (30.0%)	0.003
No	38 (95.0%)	28 (70.0%)	

Table 5 describes the late outcomes over a period of 12 months. Total surgical success, i.e., achievement of target IOP off medication, was far higher in the injection group (75.0% vs 40.0%), while qualified success rates were similar in both groups. Total failure rate was significantly lower with injection (7.5% vs 20.0%, p=0.004). Late complications were also reduced in the injection group, with not a single case of hypotony maculopathy compared with 12.5% in the sponge group (p=0.021), and fewer cataract advances (10.0% vs 30.0%, p=0.029).

Table 5: Late outcomes (12 months) (N=80)

Outcome	Injection (n=40)	Sponge (n=40)	p-value
Overall status			
Complete success (IOP target without meds)	30 (75.0%)	16 (40.0%)	
Qualified success (with meds)	7 (17.5%)	16 (40.0%)	0.004
Failure	3 (7.5%)	8 (20.0%)	
Hypotony maculopathy			
Yes	0 (0.0%)	5 (12.5%)	0.021
No	40 (100.0%)	35 (87.5%)	
Cataract progression			
Yes	4 (10.0%)	12 (30.0%)	0.029
No	36 (90.0%)	28 (70.0%)	

In Table 6, the absolute risk difference (ARD) is expressed in percentage points (pp) and reflects the direct difference in outcome rates between the injection and sponge groups. A positive ARD indicates that the injection technique improved beneficial outcomes, whereas a negative ARD indicates that it reduced adverse events compared with sponge application. The relative risk (RR) with its 95% confidence interval (CI) expresses the proportional likelihood of an outcome in the injection group relative to the sponge group; values above 1 signify increased odds of success with injection, while values below 1 signify reduced risk of complications. The number needed to treat (NNT) or number needed to treat to prevent (NNH-prevent) translates these differences into clinical practice by estimating how many patients would need to undergo trabeculectomy with injection, instead of sponge, to achieve one additional treatment success or to prevent one extra complication.

Table 6: Comparative effectiveness summary (Injection vs Sponge)

Endpoint	Injection (n=40)	Sponge (n=40)	ARD (pp)	RR (95% CI)	NNT/NNH	p value
Day-1 IOP ≤10	20 (50.0%)	8 (20.0%)	+30.0	2.50 (1.25–5.00)	3 (benefit)	0.008
Good early bleb (≤1 wk)	32 (80.0%)	18 (45.0%)	+35.0	1.78 (1.22–2.59)	3 (benefit)	0.005
Hyphema (≤1 wk)	1 (2.5%)	7 (17.5%)	−15.0	0.14 (0.02–1.11)	7 (prevent)	0.018
Shallow AC (≤1 wk)	2 (5.0%)	9 (22.5%)	−17.5	0.22 (0.05–0.94)	6 (prevent)	0.031
IOP ≤15 at ≈3 mo	30 (75.0%)	16 (40.0%)	+35.0	1.88 (1.23–2.85)	3 (benefit)	0.003
Bleb leak (≈3 mo)	1 (2.5%)	9 (22.5%)	−20.0	0.11 (0.01–0.51)	5 (prevent)	0.010
Needling required (≈3 mo)	2 (5.0%)	12 (30.0%)	−25.0	0.17 (0.04–0.61)	4 (prevent)	0.003
Complete success at 12 mo	30 (75.0%)	16 (40.0%)	+35.0	1.88 (1.23–2.85)	3 (benefit)	0.004
Hypotony maculopathy (12 mo)	0 (0.0%)	5 (12.5%)	−12.5	-	8 (prevent)	0.021
Cataract progression (12 mo)	4 (10.0%)	12 (30.0%)	−20.0	0.33 (0.12–0.84)	5 (prevent)	0.029
Intraop complication (any)	1 (2.5%)	10 (25.0%)	−22.5	0.10 (0.01–0.58)	4–5 (prevent)	0.020
Conjunctival buttonhole	0 (0.0%)	6 (15.0%)	−15.0	-	7 (prevent)	0.012

Table 7 summarizes the multivariate logistic regression analysis of surgical success at 12 months. Multivariate analysis also confirmed that the MMC injection technique was the most potent independent predictor of 12-month complete surgical success (adjusted OR 3.94, 95% CI 1.42-10.94, p=0.008) after controlling for potential confounding factors like age, sex, diagnosis, lens status, intraoperative complications, and postoperative interventions. Notably, the needling procedure requirement was associated with reduced odds of success (OR 0.21, 95% CI 0.05-0.82, p=0.025), emphasizing the benefit of achieving maximum early bleb function. The remaining baseline variables, including age, sex, diagnosis, and lens status, did not significantly influence surgical success, suggesting that the benefits of injection technique are generalizable across patient groups.

Table 7: Multivariate logistic regression analysis of surgical success at 12 months (Complete success = outcome)

Predictor Variable	Adjusted OR (95% CI)	p-value
MMC application method		
Injection (vs Sponge)	3.94 (1.42 – 10.94)	0.008
Age ≥65 yrs (vs <65)	0.72 (0.24 – 2.14)	0.557
Sex (Male vs Female)	1.21 (0.44 – 3.36)	0.705
Diagnosis (POAG vs others)	1.85 (0.61 – 5.62)	0.278
Lens status (Pseudophakic vs Phakic)	0.94 (0.29 – 3.07)	0.917
Intraop complications (any)	0.31 (0.09 – 1.08)	0.067
Needling required (yes vs no)	0.21 (0.05 – 0.82)	0.025

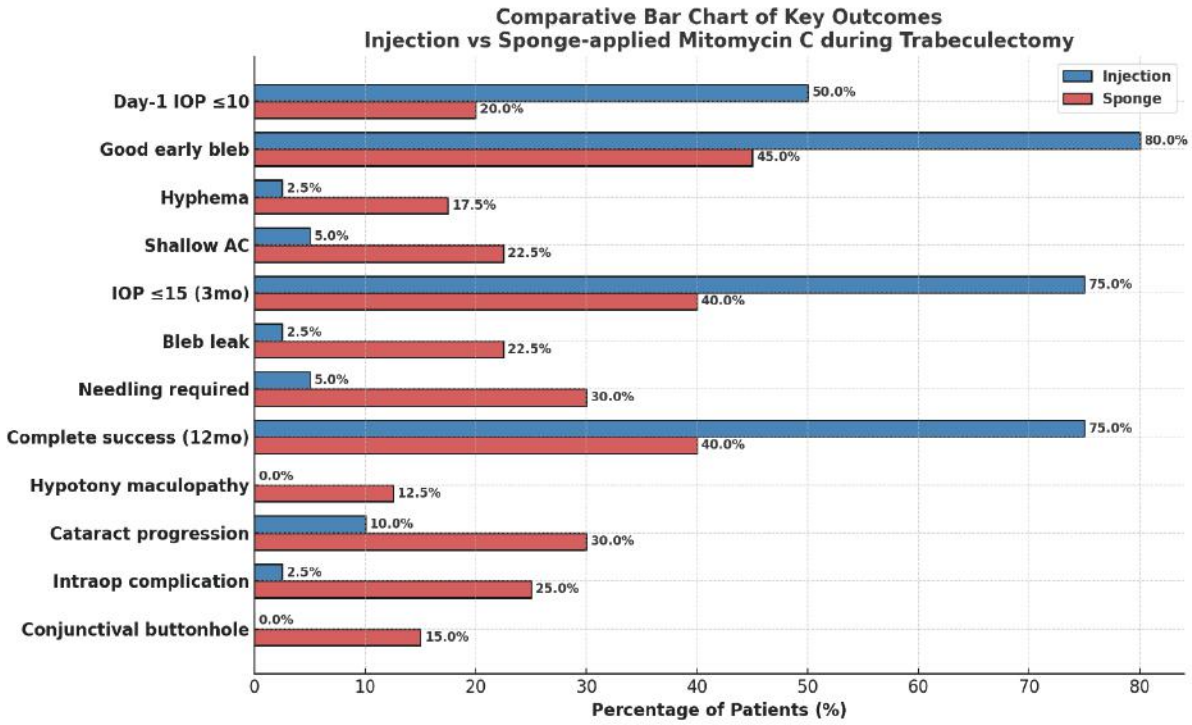

Figure 1: Comparative outcomes of intraoperative injection versus sponge-applied Mitomycin C during trabeculectomy.

The Bar chart showing the proportion of patients experiencing key efficacy endpoints (e.g., IOP control, bleb morphology, surgical success) and safety outcomes (e.g., hyphema, shallow anterior chamber, bleb leak, cataract progression). Injection consistently demonstrates higher rates of success and lower complication rates compared with sponge application.

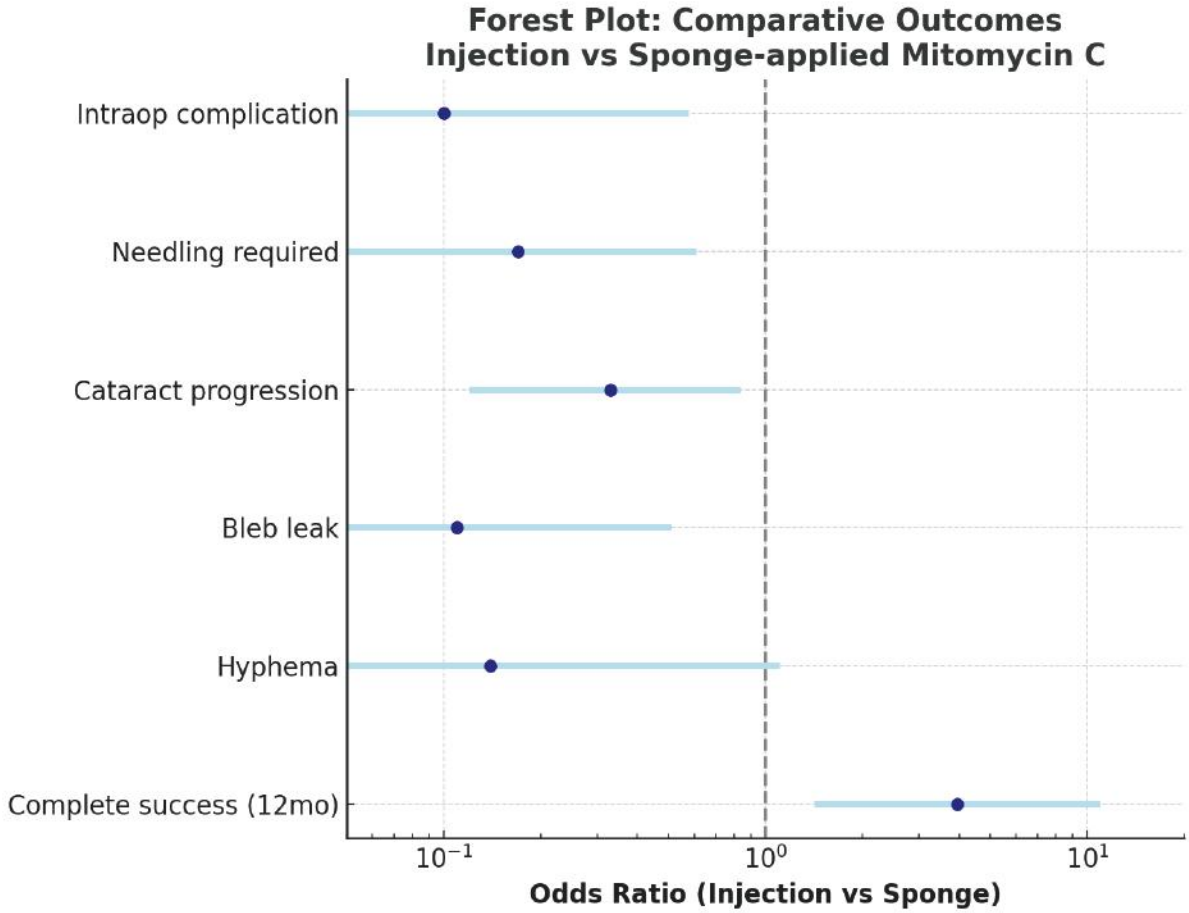

Figure 2: Forest plot of comparative outcomes for intraoperative injection versus sponge-applied Mitomycin C during trabeculectomy

Odds ratios (with 95% confidence intervals) demonstrate that injection significantly increases the likelihood of complete surgical success and reduces the risk of complications such as hyphema, bleb leak, needling, cataract progression, and intraoperative complications.

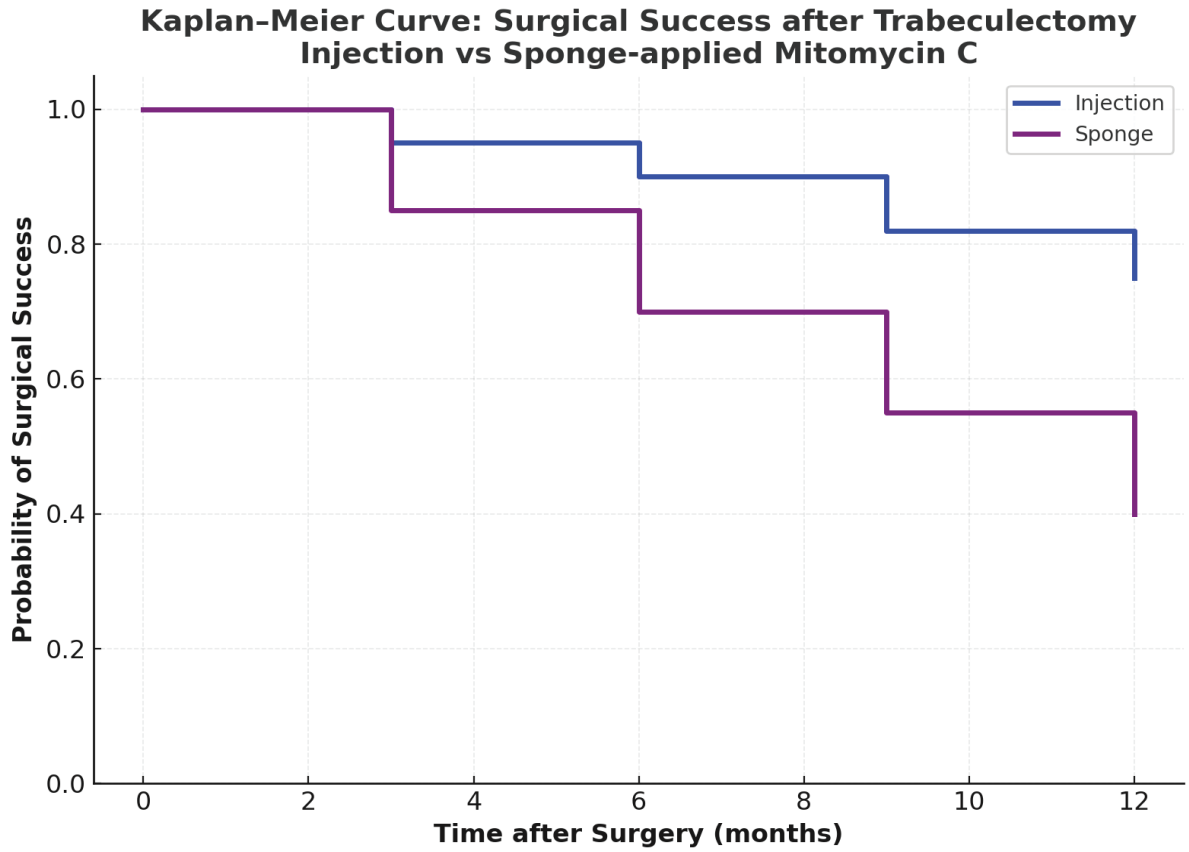

Figure 3: Kaplan–Meier survival curve of surgical success following trabeculectomy: injection versus sponge-applied Mitomycin C.

The curve shows a consistently higher probability of maintaining surgical success in the injection group over 12 months compared with the sponge group, indicating superior long-term efficacy of the injection method.

Discussion

This potential comparative trial provides strong proof that intraoperative injection using Mitomycin C is safer and more effective than standard sponge insertion in trabeculectomy. Our findings indicate a 75.0% surgical success rate with injection versus 40.0% with sponge insertion at 12 months, a highly significant improvement consistent with Pillai et al. and Maheshwari et al., in support of non-traditional MMC application [12,13]. The improved outcomes achieved with the injectable technique are attributed to several mechanistic advantages. The subconjunctival injection results in a more uniform distribution of the drug than the heterogeneous exposure produced by sponge use, potentially resulting in more evenly distributed antifibrotic effects [14]. Such uniform distribution may be accountable for the significantly better initial bleb shape observed in our injection group (80% vs 45% good blebs) because optimal bleb creation is vital to long-term success with surgery. Prevention of mechanical trauma with sponge insertion and removal most likely accounts for reduced inflammation and improved healing response, for example, decreased incidence of shallow anterior

chamber and hyphema in our injection group. Our profile of complications strongly favors the injection technique, with dramatic reductions in the number of major adverse events. The absence of conjunctival buttonhole formation in the injection group compared to 15% in the sponge group is a key safety advantage, given that conjunctival integrity is crucial for bleb function and prevention of infection [15,16]. The lower rate of 3-month bleb leakage (2.5% vs 22.5%) and lower needling rates (5% vs 30%) reflect that the injection technique creates more functionally stable and reduced tendency for over-filtration or early failure blebs. The multivariate analysis does confirm that the MMC application technique is the best individual independent predictor of surgical success (OR 3.94) when adjusting for other known risk factors. This is noteworthy since it indicates that the benefits of the injection technique are not patient-related and are most likely the result of the inherent advantage of the method of delivery itself [17]. Recent studies by Ibarz et al. and Mahmoudi et al. have shown similar results with injection techniques similar to or superior to traditional sponge usage in different patient populations [18,19]. The number needed to treat analysis is clinically helpful, the implication being that 3 patients need to be treated with injection as opposed to sponge in order to achieve one additional total surgical success. This represents substantial clinical benefit, particularly in high-volume glaucoma practice, where modest increments in success rates help large numbers of individuals. Therefore, the number needed to treat to prevent serious complications has been 4-8, which is a substantial safety improvement that can reduce morbidity in the patient and the cost of the management of complications [20]. Our 12-month results are reassuring in the long term, with the ongoing benefit of the injection technique observed in a number of parameters. The reduced prevalence of hypotony maculopathy (0% vs 12.5%) is clinically significant, since this complication can cause irreversible visual loss and is one of the most feared complications of trabeculectomy [21]. The reduced incidence of cataract progression (10% vs 30%) may be due to less intraocular inflammation and more stable anterior segment anatomy with the injection technique. The clinical significance of our findings is significant for glaucoma patients and surgeons. The injection technique has several advantages over surgery, including reduced operating time by avoiding the need for repeated sponge insertions, reduced opportunity for accidental scleral perforation, and more precise drug delivery. All these advantages, coupled with enhanced clinical outcomes, constitute a powerful case for the use of injection as the preferred method of MMC delivery in appropriate patients [22]. However, the technique must be given close attention to the volume and depth of injection to avoid complications such as accidental intrascleral injection or excessive subconjunctival fluid accumulation. Our results concur with other centers' new evidence on injection techniques, but due to the variation in MMC concentration, injection technique, and outcome assessment, direct comparisons are challenging. Today's volume of evidence supporting injection techniques promotes exploration of a paradigm shift for MMC delivery during trabeculectomy, with the possibility of improved outcomes in different patient groups and surgical settings.

Limitations of the study

The study limitations are a relatively small patient sample of 80 patients, which may limit the ability to generalize the findings to larger populations, and a follow-up of 12 months, which may avoid very late complications or long-term success rates that can be modified after a year. It was conducted at a single center with clear surgical practices and experience levels, which are generalizable to other practice settings or levels of surgeons' expertise.

Conclusion

This study demonstrates that intraoperative injection of Mitomycin C significantly outperforms traditional sponge implantation in trabeculectomy surgery. The injectable approach achieved better complete surgical success rates (75% vs 40%), better early IOP control, better bleb morphology, and significantly fewer complications like hyphema, shallow anterior chamber, and bleb leakage. Multivariate analysis confirmed injection as an independent predictor of surgical success with a nearly four-fold increase in the odds of achieving maximum success. These results support the intracameral administration of intraoperative MMC as the

preferred route of delivery for optimizing trabeculectomy outcomes and reducing patient morbidity.

Recommendations

Subsequent studies need to be multi-center randomized controlled trials with larger patient populations and longer follow-up of 3-5 years to better establish long-term safety and efficacy profiles of injection versus sponge MMC delivery. Cost-effectiveness analysis and quality-of-life measurement should also be incorporated to provide strong evidence for healthcare policy and surgical practice guideline development.

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References

1. Tham YC, Li X, Wong TY, Quigley HA, Aung T, Cheng CY. Global prevalence of glaucoma and projections of glaucoma burden through 2040: a systematic review and meta-analysis. Ophthalmology. 2014 Nov 1;121(11):2081-90.
2. Koike KJ, Chang PT. Trabeculectomy: a brief history and review of current trends. International Ophthalmology Clinics. 2018 Jul 1;58(3):117-33.
3. Sacchi M, Tomaselli D, Ruggeri ML, Aiello FB, Sabella P, Dore S, Pinna A, Mastropasqua R, Nubile M, Agnifili L. Fighting Bleb Fibrosis After Glaucoma Surgery: Updated Focus on Key Players and Novel Targets for Therapy. International Journal of Molecular Sciences. 2025 Mar 5;26(5):2327.
4. Farmer DL. Standing on the shoulders of giants: a scientific journey from Singapore to stem cells. Journal of Pediatric Surgery. 2015 Jan 1;50(1):15-22.
5. Wilkins M, Indar A, Wormald R. Intraoperative mitomycin C for glaucoma surgery. Cochrane Database of Systematic Reviews. 2005(4).
6. Fontana H, Nouri-Mahdavi K, Lumba J, Ralli M, Caprioli J. Trabeculectomy with mitomycin C: outcomes and risk factors for failure in phakic open-angle glaucoma. Ophthalmology. 2006 Jun 1;113(6):930-6.
7. Do JL, Xu BY, Wong B, Camp A, Ngai P, Long C, Proudfoot J, Moghimi S, Yan D, Welsbie DS, Weinreb RN. A randomized controlled trial comparing subconjunctival injection to direct scleral application of mitomycin C in trabeculectomy. American journal of ophthalmology. 2020 Dec 1;220:45-52.
8. Khandelwal R, Bijlani M, Raje D, Rathi A. Evaluating the efficacy of short duration Mitomycin C in safe surgery system trabeculectomy combined with cataract surgery. Clinical Ophthalmology. 2019 May 22:849-57.
9. Chakrabarty S, Kader MA, Maheshwari D, Pillai MR, Chandrashekharan S, Ramakrishnan R. Short-term outcomes of Mitomycin-C augmented phaco-trabeculectomy using subconjunctival injections versus soaked sponges: a randomized controlled trial. Eye. 2024 Apr;38(6):1196-201.
10. Uçkay I, Kressmann B, Malacarne S, Toumanova A, Jaafar J, Lew D, Lipsky BA. A randomized, controlled study to investigate the efficacy and safety of a topical gentamicin-collagen sponge in combination with systemic antibiotic therapy in diabetic patients with a moderate or severe foot ulcer infection. BMC infectious diseases. 2018 Aug 2;18(1):361.
11. Gedde SJ, Schiffman JC, Feuer WJ, Herndon LW, Brandt JD, Budenz DL, Tube Versus Trabeculectomy Study Group. Treatment outcomes in the tube versus trabeculectomy study after one year of follow-up. American journal of ophthalmology. 2007 Jan 1;143(1):9-22.
12. Pillai M, Kalegore A, Mathews A, Krishnadas S. Two routes of administration of mitomycin C in a trabeculectomy. Indian Journal of Ophthalmology. 2023 Feb 1;71(2).
13. Maheshwari D, Pillai MR, Hm P, Kader MA, Rengappa R, Pawar N. Long-term safety and efficacy of injection mitomycin C (MMC) versus sponge application in trabeculectomies. European Journal of Ophthalmology. 2025 Mar;35(2):559-67.
14. Kim M, Shin M, Zhao Y, Ghosh M, Son YO. Transformative impact of nanocarrier-mediated drug delivery: overcoming biological barriers and expanding therapeutic horizons. Small Science. 2024 Nov;4(11):2400280.
15. Wells AP, Cordeiro MF, Bunce C, Khaw PT. Cystic bleb formation and related complications in limbus-versus fornix-based conjunctival flaps in pediatric and young adult trabeculectomy with mitomycin C. Ophthalmology. 2003 Nov 1;110(11):2192-7.
16. Al-Shahwan S, Al-Torbak AA, Al-Jadaan I, Omran M, Edward DP. Long-term follow up of surgical repair of late bleb leaks after glaucoma filtering surgery. Journal of Glaucoma. 2006 Oct 1;15(5):432-6.

17. Maheshwari D, Kanduri S, Rengappa R, Kadar MA. Intraoperative injection versus sponge-applied mitomycin C during trabeculectomy: One-year study. Indian Journal of Ophthalmology. 2020 Apr 1;68(4):615-9.

18. Ibarz Barbera M, Morales Fernandez L, Tana Rivero P, Gomez de Liano R, Teus MA. Anterior-segment optical coherence tomography of filtering blebs in the early postoperative period of ab externo SIBS microshunt implantation with mitomycin C: morphological analysis and correlation with intraocular pressure reduction. Acta ophthalmologica. 2022 Feb;100(1):e192-203.

19. Mahmoudi A, Ghavimi MA, Maleki Dizaj S, Sharifi S, Sajjadi SS, Jamei Khosroshahi AR. Efficacy of a new hemostatic dental sponge in controlling bleeding, pain, and dry socket following mandibular posterior teeth extraction—a split-mouth randomized double-blind clinical trial. Journal of Clinical Medicine. 2023 Jul 10;12(14):4578.

20. Gedde SJ, Herndon LW, Brandt JD, Budenz DL, Feuer WJ, Schiffman JC, Tube Versus Trabeculectomy Study Group. Postoperative complications in the Tube Versus Trabeculectomy (TVT) study during five years of follow-up. American journal of ophthalmology. 2012 May 1;153(5):804-14.

21. Sato N, Kasahara M, Kono Y, Hirasawa K, Shoji N. Early postoperative visual acuity changes after trabeculectomy and factors affecting visual acuity. Graefe's Archive for Clinical and Experimental Ophthalmology. 2023 Sep;261(9):2611-23.

22. Bindlish R, Condon GP, Schlosser JD, D'Antonio J, Lauer KB, Lehrer R. Efficacy and safety of mitomycin-C in primary trabeculectomy: five-year follow-up. Ophthalmology. 2002 Jul 1;109(7):1336-41.